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ABSTRACT

This report describes two preliminary studies (a pilot study involving 11 children and a main study involving 24 children) that examined letters chosen in the spelling of nonsense words to determine whether children with learning difficulties in spelling exhibit systematic ways of spelling. The studies showed that phoneme-grapheme grammars differ among children with respect to the graphemes used to represent a phoneme--children with specific literacy difficulties are more likely to have graphemes with lower English contingency than children who do not have reading and spelling difficulties. The studies did not provide enough data per child to test theories of individual differences. The next study will aim to collect sufficient data so that half of it can be used to generate a phoneme-grapheme grammar for each particular child and the other half can be used to test that grammar. Three figures are included. Seventeen references, two appendixes describing the nonsense words used in both studies, and a list of 58 reports that may be obtained from the Centre for Information Technology in Education are attached. (KEH)

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# How Children Spell Nonsense Words

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# How Children Spell Nonsense Words

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**Abstract**
This report outlines a research project that aims to find out how children spell. It is proposed that children exhibit individual differences in spelling ability, differing in terms of the letter sequences they associate with particular sounds. It is suggested that they also differ in terms of the way they choose one of these letter sequences, their choice being dependent on various factors such as the position of a sound within a word, and the frequency of that sound-to-letters correspondence in the English language. This report describes two preliminary studies that were carried out to look at the letters chosen in the spelling of nonsense words.

## 1 Background

Learning difficulties in spelling are usually experienced along with learning difficulties in reading. Children with these difficulties are referred to as having *specific literacy difficulties* (SLD). The reading of the children is painfully slow and inaccurate but their spelling difficulties are often more severe. While their reading errors can make sense one way or another (the child will speak a real word aloud even if it is wrong), their spelling errors can be wildly inaccurate, the child themselves being unable to read the word back later. Some errors found by Pain (1985), for example, are:

| Target word | Spelling |
|---|---|
| chair | *chive* |
| conservative | *gusertr* |
| jewels | *treser* |
| television | *tahgfring* |
| turtle | *turend* |

The spellings are by children between the ages of 9 and 12 years. This report outlines a research project that is to examine how children spell. Two preliminary studies are described which look at the spelling of nonsense words.

### 1.1 Theoretical Approaches to SLD

Research into SLD can be summarised in terms of three theoretical approaches (Seymour, 1986). The approaches differ mainly in their *definitions* of reading and spelling difficulties.

#### 1.1.1 Dyslexia - a Homogeneous Category

The first sees children with and without SLD as two distinct groups, each sharing similar essential characteristics i.e. the groups are *homogeneous*. This view was originally put forward by the World Neurological Foundation who introduced the term "dyslexia" to describe a syndrome of reading and spelling difficulties. Some of the symptoms by which a child can be diagnosed as "dyslexic" are:

- the ability to pronounce unfamiliar words with a tendency to guess wildly at their phonetic structure [the way they sound],
- a failure to realize differences between words which are similar in spelling and sound, such as *pug-bud*, *on-no*,

- difficulty in keeping track of the correct place when reading,
- problems in switching from one line of print to the next,
- rotations and reversals of letters,
- omission of phonemes and and syllables,
- bizarre inconsistent spelling errors, and
- untidiness of penmanship. (Critchley, 1970)

A problem with this approach lies with the identification of a dyslexic child by these features (a problem common to the diagnosis of any syndrome defined in terms of a set of symptoms). Some questions that arise in the process of diagnosis, for example, are: how many of the above features need to be present before a child is diagnosed as dyslexic (Snowling, 1987)? How bad does a spelling error have to be before it is considered "bizarre"? If a child has exceptionally tidy handwriting despite having other difficulties, does this mean they cannot be classed as dyslexic?

This approach is usually taken by the medical profession and psychiatrists in particular, but is not usually held by teachers. This is because of the emphasis on categorising children irrespective of their individual patterns of difficulty. It is thought that the assumption of a common underlying deficit both stigmatises children, and fails to address their individual educational needs within the classroom.

### 1.1.2 The Homogeneous Subgroup Model

The second approach shares the view that there are two distinct groups of children, those with and without SLD. It differs from the first approach, however, in that it recognises distinct *subgroups* of difficulty within the SLD group. The subgroups differ in terms of essential characteristics of their difficulties, but within each subgroup there is homogeneity. This approach is based on two categories of *error types* that children make. The error types are supposed to reflect deficits in one processing route or the other (see Section 1.2 for a description of these processing routes). A child is defined as belonging to a subgroup depending on whether they make more of one error type than the other, or the same amount of each type (e.g. Boder, 1973; Treiman, 1984).

There are two problems with this approach. Firstly, if a child makes mostly one type of error and is thus placed in subgroup A, say, how does this account for the residue of errors that are characterized by subgroup B? Also, how many more errors does a child have to make of one type or another before they qualify for a particular subgroup?

Another problem with this approach lies in the original definition of error types. If a spelling is wrong, but sounds like the intended word, it is referred to as a *phonetically accurate* error. The conclusion is that the child can accurately convert sounds to spellings, even though the spellings that are chosen are the wrong ones. They do not, however, have an overall image of the word against which this spelling can be checked. Thus their *phonological route* is intact but there is a deficit in their *sight vocabulary*.

The second type of error is *phonetically inaccurate* i.e. it does not read like the intended word. This category contains basically the residue of errors that do not come under the first category. Because this second error type is the converse of the first, i.e. anything that is not of the first type is automatically of the second type, it is inferred that the underlying processing deficits are similarly the converse of those explaining the first error type. Thus it is concluded that there is a deficit in the phoneme-grapheme conversion route.

Unlike the first error type, this inference is not based on an explanation of the actual spelling. Instead, the spelling is usually dismissed as undecipherable, or "bizarre" (Boder, 1973). The explanatory power of this approach is therefore limited on three related grounds: (a) the negative definition of the second error type, (b) the identification

of subgroups based on these error types, and (c) the inconsistent inference mechanisms used to explain the child's spelling processes.

### 1.1.3 Specific Literacy Difficulties.

The third approach is taken by educationalists. The qualitative variability in children's reading and writing development gives rise to the *heterogeneous* model of literacy difficulties. According to this model it is possible for any child to display any of the above features of "dyslexia" as part of the normal development of literacy skills. If a child has an unexpected problem in one area they should be identified on those grounds alone and their individual difficulties addressed at an individual level.

It is the identification of these specific difficulties that results in the children being referred to as having *specific literacy difficulties* (SLD). The use of this term is not supposed to imply any causative factors, but implies that there is further information available as to the actual nature of that child's difficulties. This may include a more specific description of the observed problem, e.g. their handwriting is undecipherable, or something which may be a contributing factor to the observed problem, such as having suffered brain damage as a child. Thus the term SLD serves largely to inform various educational bodies about the individual difficulties experienced by a particular child that need to be addressed.

## 1.2 The Dual-Route Model of Spelling

The theoretical framework used in the current project is the generally accepted *dual-route model* (Barry and Seymour, 1988). The two routes of this model are the *lexical route* and the *non-lexical route* (Figure 1). The model is similar to the dual-route model of reading, except that the processes are reversed.

### 1.2.1 The Lexical Route

The dual-route model holds that the spelling of a word is sometimes stored as a whole unit. Because of the holistic nature of this unit, it is referred to as the word's *orthographic representation* (OR). The orthographic representation involves information about the length and overall shape of the word. This is in addition to information about individual letters and their positions, or *graphemic information* (GR). Spelling by the lexical route simply involves retrieval of this orthographic representation.

The orthographic representation can usually be retrieved directly by association with its phonetic representation, i.e. as soon as it is heard, the spelling is known. However, in the case of *homonyms* (words which sound the same but have different meanings), the meaning of the word first needs to be established in order to know which OR is required. Thus an orthographic representation can be associated with the meaning of the word, or its *semantic representation*. Once the meaning has been disambiguated, the correct OR can be accessed. Thus the OR can be retrieved either directly or indirectly.

An OR becomes established in the lexicon either as a result of its having been learnt, or as a result of its having been read frequently, i.e. the word's shape has become familiar. Thus, those words that have not been learnt "off by heart" or have not been read often will not have a lexical representation.

Other terminology is sometimes used to refer to the lexicon. Boder (1973), for instance refers to it as the "sight vocabulary". It has also been called the "visual memory" (Logan et al,1988) and "specific word associations" (Treiman, 1984). Campbell (1983) refers to the lexical route as the 'lexico-semantic' process, while Pain (1985) refers to it as the 'visuo-orthographic route'.

### 1.2.2 The Non-Lexical Route

In the non-lexical route, a word's phonetic representation is translated into its graphemic representation via 3 stages:

1) *Segmentation* - the word is broken down into its constituent sound units, or *phonemes*. Each phoneme is of either a consonant or vowel type.

2) *Phoneme-grapheme conversion* - each phoneme is mapped onto a letter or combination of letters, i.e. a *grapheme*.

3) *Restringing* - the graphemes are put back together to make a word.

Because of the importance of sound in this route, it has also been referred to as the *phonological route* (Pain, 1985) and the *phonetic route* (Boder, 1973). Most words can be spelt phonetically as well as lexically if they have a regular spelling pattern, i.e. there exist the correspondences for representing each phoneme.

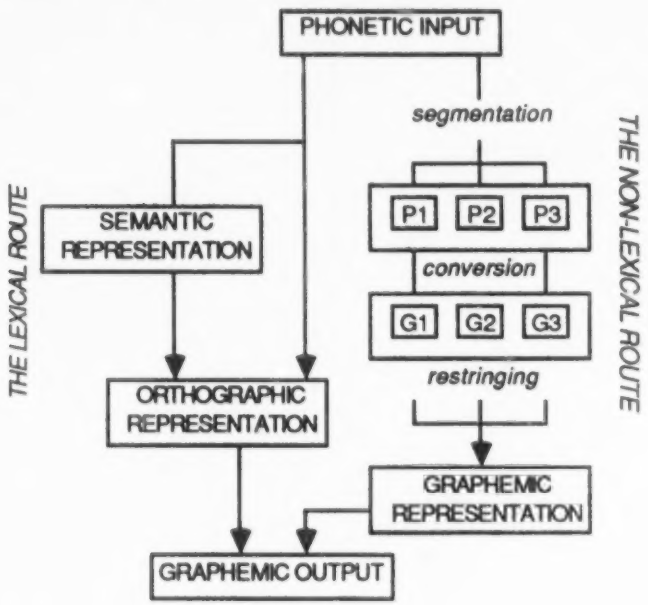


Figure 1. The dual-route model of spelling.

Real words with irregular spellings cannot be processed correctly via this route since the appropriate correspondences are not available. For instance, the word 'yacht' would either have to elicit the graphemic representation **ach** for the vowel /o/ or **cht** for the consonant phoneme /t/ depending on how the word was segmented initially.

However, the phonological route is the only way of spelling nonsense words. They can not be processed via the lexical route because they have no lexical representation. Nonsense words are therefore frequently used to investigate processing in the phonological route.

## 1.3 Current Research into Non-Lexical Processing

The dual-route model of spelling is described above. Within the context of this model recent research has focussed on the non-lexical route, in particular in the processes involved in the stage of phoneme-grapheme conversion.

One feature of the English language is that a phoneme can usually be spelt in a number of ways (Gleitman and Rozin, 1977). For example, 10 graphemic representations of the vowel phoneme /u:/ are listed below:

| Phoneme | Grapheme | Example |
|---|---|---|
| /u:/ | ou | you |
| | ue | true |
| | ough | through |
| | o | who |
| | oe | shoe |
| | oo | boot |
| | ew | crew |
| | oo(C)e | loose |
| | iu(C)e | juice |
| | u(C)e | crude |

Because there are several representations of a phoneme, there must be some way of choosing one of them when spelling a word by the non-lexical route, i.e. some *grapheme selection strategy* must be used. Recent research into spelling has identified three factors which may affect the selection of graphemes (Barry and Seymour, 1988; Barry, 1988; Campbell, 1983; Campbell, 1985). These are *contingency*, *lexical priming* and *associative priming*.

*Contingency*.
Contingency is the frequency with which a phoneme-grapheme correspondence is found in written English. It is the main factor in grapheme selection, with the likelihood of selection increasing as the contingency of a grapheme increases. Thus, in selecting a grapheme for the phoneme /u:/ (given in the example above), the highest contingency grapheme would be most likely to be selected.

The contingency values used by Barry and Seymour (1988) were derived from words generated by a computer program. All the words were of a consonant cluster - vowel cluster - consonant cluster (CVC) pattern. All nonsense words were removed, and the frequency of graphemic representations was noted.

*Lexical Priming*.
The Barry and Seymour study followed on from the work of Campbell (1983 and 1985). Using nonsense word spelling as a way of investigating non-lexical spelling, she found that the choice of a grapheme could be additionally influenced by the spelling of a real word that had just been heard. In the spelling of the nonsense word /prein/, for example, hearing the preceding word "brain" would make it more likely to be spelt "prain". Hearing the preceding word "lane" would make it more likely to be spelt "prane". The preceding word is called the *prime*.

The spelling of the vowel phonemes in these studies were thus influenced by the known spellings of real words. As a result it is concluded that the spellings were taken from orthographic representations in the lexicon. Hence this influence upon grapheme selection is referred to as *lexical priming*.

*Associative Priming*.
In lexical priming described above, the orthographic representation of a prime is accessed directly. Since in lexical spelling an orthographic representation can also be accessed via a semantic representation, it is currently thought that the orthographic representation of a prime can also be indirectly accessed. For example, if the word "detergent" is written before the nonsense word /boap/, a link, or *association*, could be made between the semantic representations of "detergent" and "soap". The orthographic

representation of "soap" can then be accessed, providing the priming grapheme for the nonsense word. As a result, /boap/ should be more likely to be spelt "boap".

Less research has focussed on the origin of contingency values used in non-lexical spelling. Because an individual has to be aware of phoneme-grapheme correspondences in real words to be aware of contingency, contingencies could be derived directly from the orthographies of known words, i.e. from the lexicon.

In the Barry and Seymour study, contingencies were taken from the English language generally. It is possible that their battery of computer-generated words *were* all known, and therefore accurately mirrored the contingencies drawn upon by the subjects. However, it cannot be assumed that the frequency of correspondences in the English language is a basis for every individual's notion of contingency. In the case of children who are learning to read and spell it is highly unlikely that they are aware of grapheme contingencies in English generally until they have developed an extensive vocabulary. According to some theorists (e.g. Ehri, 1985) this does not happen until the later stages of literacy development. The child first learns about individual letter shapes, names and pronunciation followed by knowledge about letter combinations. It is only after this knowledge has been acquired that whole word spellings are learnt.

It is therefore suggested that a child's awareness of phoneme-grapheme contingencies are not be represented by frequencies within the English language generally, but develop as their lexical knowledge develops. As a result, the graphemes that are available to represent a phoneme will be dependent on that child's sight vocabulary. The contingencies of these graphemes will also be dependent on the sight vocabulary, as will priming effects (hearing a real word will only prime the spelling of a nonsense word if the spelling of the real word is actually known).

On the basis of this, it is suggested that individual differences in spelling can, at one level, be accounted for by individual sight vocabularies which are responsible for generating contingency values. A child's repertoire of phoneme-grapheme correspondences are likely to be either subsets of the full set of English phoneme-grapheme correspondences (as generated by the computer in Barry and Seymour's study) or, in the case of children with specific literacy difficulties, highly individual phoneme-grapheme grammars that are responsible for generating spelling errors.

# 2 The Research Project

The aim of the project is to test a theory of individual differences in children's spellings by modelling them with a computer program. The theory holds that children with learning difficulties in spelling exhibit systematic, if incorrect, ways of spelling. Individual differences in spelling strategies are investigated within the framework of the dual-route model of spelling. To narrow the focus of the project, only processing within the non-lexical route is being investigated.

## 2.1 A Theory of Individual Differences

Within the non-lexical route, it is suggested that individual differences exist in two interacting forms. These are (a) *phoneme-grapheme grammars*, and (b) *grapheme selection strategies*.

### 2.1.1 Phoneme-Grapheme Grammars

The first hypothesis specifies that each child possesses a set of sound-to-spelling correspondences. This means that each discrete sound unit, or *phoneme*, maps onto a

number of letter combinations, or *graphemes*. For example, the vowel sound /ei/ as in the word 'late' might have the following mappings:

| *Phoneme* | | *Grapheme* | *Examples* |
|---|---|---|---|
| /ei/ | -> | a(C)e | late, paste |
| | | ai | wait, bait |
| | | a | bass |

where (C) represents a graphemic consonant string (one or more consonants). This is the representation grammar for the phoneme /ei/. The whole set of mappings for consonant and vowel phonemes constitutes the *phoneme-grapheme grammar* of that child. In this project, only the phoneme-grapheme grammar for vowel phonemes will be examined.

### 2.1.2 Grapheme Selection Strategies

Given that a phoneme can be represented graphemically in a number of ways, there must exist some way of selecting one when spelling via the non-lexical route, i.e. there must be one or more *grapheme selection strategies*. The second hypothesis of individual differences is, therefore, that these selection strategies differ between individuals. It is proposed that the differences are in terms of a child's sensitivity to two factors: *context* and *contingency*.

#### i. Context Effects

The *context* of a phoneme in non-lexical spelling is the word in which it is presented. The selection of a grapheme can therefore be influenced by any of the following factors:

(a) the length of the word,
(b) the position of the phoneme in the word,
(c) the phonetic structure of the word,
and (d) the nature of preceding and following phonemes.

For example, the effects of phonetic, or word, structure on the graphemic representation of the vowel phoneme /ei/ (as in 'late') in a monosyllabic word might be as follows:

| *Phoneme* | *Word Structure* | *Examples* | *Grapheme* |
|---|---|---|---|
| /ei/ | CV | pay, tray | ay |
| | VC | eight | eigh |

where C represents a consonant phoneme and V represents a vowel phoneme.

#### ii. Contingency Effects

"Sound-to-spelling contingency" (Barry and Seymour, 1988) refers to the likelihood with which an individual thinks a phoneme will be spelt one way or another. It is based on the frequency of phoneme-grapheme correspondences in the lexicon, i.e. in words that have an orthographic representation. In adults with an extensive vocabulary, this will be similar to the frequency of phoneme-grapheme correspondences in English text - this was the measure of contingency used in Barry and Seymour's study. Here it is referred to as *English contingency*.

In children who are learning to read and are gradually acquiring more orthographic representations, contingency will be dependent on their stage of learning, i.e. how much they can read by the lexical route. Since the state of one child's lexical knowledge is different from another's at any one time, and changes as that child learns more words, the likelihood with which a child thinks phonemes can be represented one way or another are referred to as *individual contingencies*. In the case of children who do not

have difficulties in learning to read and write, the lexicon might be a subset of English such that their individual contingencies reflect English contingencies. In children with SLD, individual contingencies can be quite different to English contingencies.

## 2.2 Research Methodology

One aspect of artificial intelligence research is that it can be used to further our understanding of psychological, or "cognitive" processes underlying procedural skills. The idea is that a theory of cognitive processes, like that above, can be tested by simulating the hypothesized processes. The simulation takes the form of a computer program which is based on the theory. If, given some information about the previous performance of a child, the program can successfully predict future performance, it can be used as evidence to support the original theory. This methodology is referred to as *cognitive modelling*. It has previously been used to test theories of cognition underlying mathematical skills (Young and O'Shea, 1981; Payne and Squibb, 1988).

In the current project, the input to the program will consist of a phoneme-grapheme grammar and grapheme selection strategies. These will have been derived from half the spelling data obtained from a child. The performance of the program will be tested against the other half of the data - if the output matches the child's spellings it will have successfully modelled that child's performance. The program will be run against a number of children since the more children it can model, the stronger the support for the theory of cognition.

# 3 The Pilot Study

A pilot study was carried out which looked at the spelling of nonsense words by children with specific literacy difficulties. In Section 1.3 it was suggested that the effects of lexical priming will, in the case of children, depend more heavily than in adults, on the sight vocabulary of the child. The aim of this study was to examine the relationship between the sight vocabularies and the spelling of nonsense words by individual children.

## 3.1 Design

To examine the relationship between the spelling of nonsense words and a child's contingency values, some measure of those contingencies was needed. Earlier it was suggested that contingency values derive from the frequency of phoneme-grapheme correspondences in the lexicon. If an exhaustive list of ***known*** words containing a phoneme could be obtained, it was thought that this would adequately reflect the range of phoneme-grapheme correspondences for that phoneme in the lexicon. To generate these words, a child was asked to say all the rhyming words they knew and write them down.

The frequency with which different spellings of that phoneme occurred would further reflect the contingency of each spelling. The spelling with the highest contingency would be that which occurred the most often in the known words i.e. the *majority spelling*.

Where the nonsense word was written after writing the real words, the *last real word* was taken to be a possible prime word as it was heard just before the writing of the real word.

It was thought that another priming effect might occur by *highly significant* words in the lexicon, whether or not they had been heard just before writing the nonsense word. For example, the name 'Kay' would be a significant word for a child whose name was 'Kay', and this might make it more likely that the phoneme /ei/ would be spelt **ay**. In the writing of the rhyming words, the most significant word was taken to be the *first rhyming word* that was thought of.

Comparison of the spelling of the nonsense word against the majority spelling, the first spelling and the last spelling of the real words was examined as a way of seeing how non-lexical spelling was influenced by the sight vocabulary.

### 3.2 Method

#### 3.2.1 Subjects

The subject group consisted of 11 children, 9 boys and 2 girls, who had been identified as having specific literacy difficulties. Their mean chronological, reading and spelling ages are tabulated in Figure 2. Reading age was calculated on the Neale Analysis of Reading Scale (Neale, 1958) and spelling age on the SPAR spelling and reading test (Young, 1976). These are standardised measures that are used to identify children with specific literacy difficulties. Difficulty, or 'retardation', is usually measured as the difference between spelling or reading age and chronological age. The mean retardations in spelling and reading are included in Figure 2. In children with SLD, spelling is usually more impaired than reading. In this group, however, the difference between mean reading and spelling ages is not significant ($p_{1tail}$=0.3163, df=9) implying that the subjects were equally impaired in both skills.

The children had received extra tuition for a duration of between 6 months and 2 years 10 months. Six had been attending a learning centre for 2 hours a week; the other five were visited in their schools for 2 hours a week.

#### 3.2.2 Materials

A total of 15 vowel phonemes were used (see Appendix A). Five of these were *consistent* vowels and 10 were *inconsistent* vowels. Consistency refers to the number of graphemic representations for that phoneme that can be found in the English language. A consistent vowel is one for which at least 90% of monosyllabic words with that sound contain the same spelling. The consistent vowels are also sometimes referred to as the five 'short' vowel sounds, and are found in the words 'cat', 'pet', 'bit', 'pot' and 'cut'. Inconsistent vowels are those for which the most common spelling pattern occurs in less than 70% of the words containing that vowel sound. Some examples are the vowel sounds in 'work', 'mind', 'leap', 'fowl' and 'talk'.

A monosyllabic nonsense word was devised for each of the 15 vowel sounds. The words were all of a CVC (consonant-vowel-consonant) pattern. As far as possible, the nonsense word was taken from the example of the most common spelling pattern given by Barry and Seymour, but with the initial consonant cluster replaced by a single consonant to make a nonsense word. Where the example ended with a consonant cluster, this was also replaced with a single consonant since it was thought that this would make it easier for the children to think of and write the rhyming words.

| MEASURE | N | MEAN (years) | S.D. |
|---|---|---|---|
| Chronological Age (CA) | 11 | 10.43 | .99 |
| Reading Age (RA) | 10 | 8.17 | .86 |
| Spelling Age (SA) | 11 | 8.27 | .90 |
| CA - RA | 10 | 2.17 | .79 |
| CA - SA | 11 | 2.15 | .68 |
| RA - SA | 10 | 0.07 | .45 |

Figure 2. Chronological, reading and spelling ages of the children in the pilot study.

### 3.3 Procedure

Ten of the children were presented all 15 nonsense words; one was given only the five short vowel nonsense words owing to lack of time. Each child was first asked to repeat the nonsense word after the experimenter had said it to make sure that it had been heard properly. Once they had heard the nonsense word correctly, they were either asked to write it down immediately or go straight onto the rhyming words depending on the writing order for that nonsense word (see "Writing Order" below). They were then asked to say and write down each real word they could think of that rhymed with the nonsense word. Where the child could not think of rhyming words, semantic clues were given by the experimenter. For instance, in thinking of words that rhymed with /ked/, a child might be asked, "What do you call this thing on your shoulders?". When they replied with the right word, i.e. 'head', they wrote it down.

Three procedure variables were introduced during the course of the experiment. These were:

(i) the order of presentation,
(ii) masking, and
(iii) the order of writing.

#### 3.3.1 Presentation Order

At the beginning of the experiment, the 10 inconsistent vowel nonsense words were given first, followed by the 5 consistent vowels. This was because the attention span of children with specific literacy difficulties is relatively short, and as it was expected that they would find the inconsistent vowels more difficult to find rhymes for (as they are rarer), they were given first.

However, during the experiment it became apparent that despite finding it easier to think of rhyming words for the consistent vowels, the children sometimes found the whole concept of rhyming difficult. They found rhyming easier after they had done it a few times. Because of this, it was decided to give the (easier) consistent vowels first as practice in rhyming. Success in generating rhyming words for these appeared to give the children more confidence for tackling the later, more difficult sounds. The presentation order was therefore changed from inconsistent-consistent to consistent-inconsistent from the third child onwards.

### 3.3.2 Masking

Masking was introduced after it was noticed that, in writing the rhyming words, the children were simply copying down the spellings of the preceding words without thinking about them. From the sixth subject onwards, each word that was written down was immediately covered with a piece of paper before the next rhyming word was thought of.

### 3.3.3 Writing Order

The writing order for each nonsense word was the order in which the word and its rhyming words were written down. Three conditions of writing order were introduced as it was thought that writing order would affect priming.

*(i) Nonsense word - rhyming words*
In the first condition, the nonsense word was written down immediately after it had been heard correctly by the child. The rhyming words were then written down afterwards.

*(ii) Rhyming words - nonsense word.*
In the second condition, the child was told the nonsense word and asked to say it *without* writing it, then asked to write all the rhyming words they could think of. Finally they were asked to write the nonsense word.

This writing order was introduced after it was thought that the spelling of the nonsense word, however it was spelt, could prime the spelling of the first real word. Obviously, if the nonsense word was primed by the most significant word, and the most significant word is the first real word, then the nonsense word and the first real word will be spelt similarly. However, if the nonsense word was spelt some other way and this primed the spelling of the first real word, the first real word could still be thought of as the most significant word but its spelling could not be taken as its lexical representation. In this condition, the spelling of the first real word *can* be taken as unprimed and therefore as its lexical representation.

*(iii) Nonsense word - rhyming words - nonsense word.*
In the third condition, the nonsense word is written both before and after the rhyming words. This is a direct test for the effect of the intervening rhyming words on the spelling of the nonsense word. If both spellings of the nonsense word are identical it can be concluded that the actual writing of the rhyming words has no effect.

## 3.4 Results

The results are described for each writing order condition.

***(i) Nonsense word - rhyming words.***

In this condition, the nonsense word was written first followed by the rhyming words. An example of the data produced under this condition is given below.

| *Nonsense word* | *Child's spellings* | *Real word* |
|---|---|---|
| /sork/ | **sork** | |
| | **pork** | (pork) <- First spelling |
| | **tork** | (talk) |
| | **walk** | (walk) |
| | **kork** | (cork) |

| | |
|---|---|
| **hork** | (hawk) |
| **fork** | (fork) |

[Majority spelling = **or**]

A total of 25 phonemes (i.e. 25 nonsense words) were presented under this condition. The total number of rhyming words generated was 148, giving an average of 5.92 rhyming words per nonsense word. 72% of the nonsense word vowels were spelt the same as in the first real word; 80% were spelt the same as the majority of real word spellings. 25% of the nonsense words were spelt differently to both the first real word and the majority of spellings. The words that were spelt the same as the first real word were also spelt the same as the majority. Only 2 were spelt the same as the majority but not the same as the first real word.

***(ii) Rhyming words - nonsense word.***

In this condition, the children repeated the nonsense word without writing it, and then wrote down all the rhyming words they could think of. Finally they were asked to write down the nonsense word. An example of data collected under this presentation condition is given below.

| *Nonsense word* | *Child's spellings* | *Real word* | |
|---|---|---|---|
| | **led** | (lead) | <- First spelling |
| | **bed** | (bed) | |
| | **wed** | (wed) | |
| | **head** | (head) | |
| | **dead** | (dead) | |
| | **shead** | (shed) | |
| | **bead** | (bread) | <- Last spelling |
| /ked/ | **ced** | | |

[Majority spelling = **ea**]

A total of 103 nonsense words were presented under this condition, and a total of 559 rhyming words were produced. This meant that each child produced, on average, 5.43 rhyming words for each nonsense word. Approximately half the rhyming words were written under the masking condition, i.e. the child covered each spelling up with a piece of paper after it had been written.

Of the 103 presentations, 85 (83%) of the nonsense words were spelt the same as the first real word, 93 (90%) were spelt the same as the majority spelling and 76(74%) were spelt the same as the last real word.

***(iii) Nonsense word - rhyming words - nonsense word.***

A total of 27 presentations of phonemes were made under the third condition, where the child was asked to spell the nonsense word both before and after spelling the real words. A total of 131 rhyming words were generated, which meant that an average of 4.85 rhyming words were produced for each presentation of a phoneme. An example of the data collected under this presentation condition is given below.

| *Nonsense word* | *Child's spellings* | *Real word* | |
|---|---|---|---|
| /yope/ | **youpe** | | |
| | **slop** | (slope) | <- First spelling |

| | | | |
|---|---|---|---|
| | **cope** | (cope) | |
| | **moap** | (mope) | |
| | **soap** | (soap) | |
| | **rope** | (rope) | |
| | **hoap** | (hope) | <- Last spelling |
| /yope/ | **yupe** | | |

[Majority spelling = **oa**]

In 22 out of the 27 presentations (81%) under this condition the spelling of the nonsense word was the same both before and after writing the real words. Of these 22, 4 spellings of the nonsense word were the same as the majority spelling only, 1 was the same as the first real word only, and 14 (64%) were the same as both the majority spelling and the first real word.

### 3.5 Discussion

In the first writing condition, most spellings of the nonsense words were the same as both the majority spelling and the first word. Because of the possibility of the spelling of the nonsense word priming the spelling of the first real word, it could not be concluded that the spelling of the real word reflected its orthography as stored in the lexicon. Therefore the second writing condition was introduced. Another problem with the data collected under the first writing condition was that there was no masking during the writing of the rhyming words. In some cases it was obvious that the child was assuming that because consecutive words rhymed their spellings were the same; consequently the previous spelling pattern was copied for each new word. It was because of this that masking was introduced.

The results under the second condition were very similar to the results under the first condition. Most of the nonsense words were spelt the same as the majority spelling, which was the same as the possible primes - the first real word in the first condition and the last real word in the second condition. Because of this it is not clear whether the nonsense word had been spelt according to contingency (majority spelling), recency (last real word spelling) or lexical priming (first real word). Any recency effect would be further confounded by the fact that half of this data was collected with the masking condition and half without.

In the third condition it was found that most of the first and second spellings of the nonsense word were the same. The conclusion drawn from this was that the intervening rhyming words had no effect. Obviously it would not have been possible for the last real word to be responsible for priming both spellings of the nonsense word, since it was spelt after the first nonsense word. However, it was thought possible for the majority spelling to determine both spellings, or for the first real word to prime both (as the most significant prime in the lexicon). Neither of these effects could actually be established because in most cases both nonsense word spellings were the same as the majority spelling and the first real word spelling. In addition, an assumption in this condition was that any difference between the two spellings of the nonsense word would have been *caused* by the intervening rhyming words. This implies that there is consistency in the way in which nonsense words are spelt, and that without any intervening nonsense words, they would have been spelt the same way.

The findings mentioned above could not be resolved due to there not being anough data. Despite the inconclusive findings, however, this study served to highlight methodological and theoretical assumptions that were made.

Firstly, it was assumed that because a child knew a word, i.e. could say it when given a semantic clue, that it would be spelt via the lexical pathway by copying out its orthographic representation in the lexicon. It is obvious that this assumption should not have been made since it possible to know a word's sound and meaning without knowing how to spell it, i.e. there can be a semantic representation in the lexicon without there being an orthographic representation. This would be the case with illiterate adults. Thus the spelling of the real words can not be taken as indicative of orthographic representations in the lexicon.

A consequence of this assumption was a second assumption: that the grapheme with the highest contingency could be obtained from the majority spelling. Because the semantic and orthographic representations were confused during the experiment, the majority spelling of the rhyming words clearly did not reflect the highest contingency grapheme in the lexicon. In addition to this, the semantic cuing of some of the rhyming words meant that the words were probably of more significance to the experimenter than to the child, such that they were possibly more indicative of the frequency of graphemic representations held by the experimenter than of the child. Generally, then, the results are of limited validity since they are not measuring what they were expected to measure.

Because of these limitations a second study was devised. This study looked more closely at non-lexical spelling of vowel phonemes by getting children to spell a phoneme more than once in different nonsense words. No real words were involved in this study as there was no way of unambiguously accessing the orthographic contents of the lexicon. An important feature of this study was that stimulus lists were carefully organised in order to avoid priming effects.

## 4 The Main Study

The main study was an investigation of non-lexical spelling in children with and without SLD.

### 4.1 Design

To examine graphemic representations of a phoneme, children were to be given more than one nonsense word containing that phoneme. The format of the nonsense words was again to be restricted to a CVC pattern. Only five vowel phonemes were to be examined. This was because it was expected that an individual would be aware of more than one way of representing a phoneme and so that phoneme would have to be presented a number of times before all representations of it were manifestd. If all phonemes (12 vowel sounds and 13 consonants) were presented enough times, the total number of items in the test would be too great to retain a child's concentration. This might result in a position effect i.e. the position of the word in the list would affect the way it was spelt. Therefore, in order to keep the number of independent variables down, only five phonemes were chosen. These were the five long vowels: /ei/, /i:/, /ai/, /ou/ and /u:/.

### 4.2 Method

#### 4.2.1 Subjects

The study involved 24 children from primary schools in the area of Exeter, Devon. 12 of these were receiving extra reading and writing tuition, having been identified by the local education authority as having "specific literacy difficulties" (SLD). Each child in this group was matched for chronological age (school year) and sex against a child without SLD. The mean chronological age (CA) and reading age (RA) of each group

are shown in Figure 3. The difference between the CA and RA is also shown for each group. Reading age was measured on the Neale Analysis of Reading scale (Neale, 1976). No spelling age data was available for this study.

| | SLD (N=12) | NON-SLD (N=12) | Mean Difference (SLD - NON-SLD) |
|---|---|---|---|
| Chronological Age (CA) | 10.38 (1.05) | 10.41 (1.08) | -0.25 |
| Reading Age (RA) | 8.33 (0.93) | 10.48 (1.16) | -2.81* |
| Mean Difference (CA - RA) | 2.05** | -0.71*** | |

Figure 3. Mean chronological and reading ages of the subject groups (standard deviations in brackets).
* $p_{1\ tail}<0.0001$,df=11, ** $p_{1\ tail}<0.0001$,df=11, *** $p_{2\ tail}<0.05$,df=11

As expected, reading age within the SLD group was lower than chronological age ($p_{1\ tail}<0.0001$, df=11) indicating a significant mean retardation in reading ability for that group. Also as expected, the mean reading age of the SLD group was significantly lower than that of the non-SLD group ($p_{1\ tail}<0.0001$, df=11). The reading age of the non-SLD group was actually slightly higher than the chronological age ($p_{2\ tail}<0.05$, df=11) indicating that this was a group of above-average reading ability.

### 4.2.2 Materials

The five vowel phonemes used in this study are given below. An example of a monsyllabic CVC real word containing each phoneme is also given.

| *Phoneme* | *Example* |
|---|---|
| /ei/ | late |
| /i:/ | feet |
| /ai/ | white |
| /ou/ | coat |
| /u:/ | boot |

A list of nonsense words was made up as follows: all monosyllabic CVC nonsense words for each of the five phonemes, starting with any consonant and ending in the consonants /d/ or /t/, were written down. The terminating consonants were restricted to /d/ and /t/ because otherwise there would still be too many words in the list. A few nonsense words with a /t/ ending were removed so that there was an even number of /t/ and /d/ endings. This is so that the words with different endings could be given alternately. The final list consisted of 44 nonsense words, with an average of eight words per phoneme (see Appendix B).

A stimulus list was constructed for each subject. In each case, there were three *masking conditions* that the stimulus list had to satisfy. This was because, from the pilot study, it appeared that the way children spelt a word was influenced by their spelling of earlier words which rhymed. The three masking conditions were that no word in the list should be next to another if they had:

1) the same initial consonant,
2) the same vowel sound, or
3) the same terminating consonant.

Each word in the stimulus lists was followed by a word with a different initial consonant, a different vowel phoneme and a different terminating consonant. The stimulus list was different for each subject.

### 4.2.3 Procedure

Each subject was told that they were to be given a list of nonsense words which they were to spell according to how they thought they might be spelt. It was emphasised that the words were meaningless and that there was actually no right or wrong way of spelling the word, but it was how they thought each sound was spelt that was important. They were told they had to repeat each word after it had been spoken by the experimenter and then to write it down. They were also asked to cover up each word with a piece of paper after they had written it.

## 4.3 Results

A quantitative analysis was carried out to look for differences between the two groups in the way in which nonsense words were spelt. To this end, the *regularity* of the spellings of each word was compared. According to Solso and Juel (1980), it is possible to assess the orthographic regularity of any letter sequence by calculating the *sum of bigram frequencies* (SOBIF). A bigram frequency is a score denoting the number of times a bigram (two letters in succession) appears in a certain position in a word of a certain length, per one million words. Thus, the SOBIF for the word 'head' would be 5919, calculated as follows:

Bigrams in 'head' = HE, EA, AD
No. of letters in 'head' = 4

| *Bigram* | *Position* | *Frequency (for 4-letter word)* |
|---|---|---|
| HE | 1-2 | 2252 |
| EA | 2-3 | 3613 |
| AD | 3-4 | + 54 |
| | | 5919 |

By comparison, the SOBIF for the nonsense word 'tead' is 703+3613+54 = 4370. The SOBIF for the nonsense word 'teed' is 703+5163+1424 = 7290, indicating that this spelling is more orthographically regular than 'tead'.

The SOBIF for every spelling by the subjects was calculated, and the average SOBIF for each subject was worked out, i.e. the total of 44 SOBIFs was divided by 44. The mean of each of the two groups was then taken and compared, i.e. for each group, the subjects' mean SOBIFs were totalled and divided by 12. The mean SOBIF score of the non-SLD group was found to be significantly higher than that of the SLD group ($p_{1\ tail}<0.005$).

## 4.4 Discussion

An immediate conclusion to be drawn from this result is that the spellings made by children with specific literacy difficulties are less regular than those of children who do not have SLD. At first it might appear obvious that children with SLD will spell less regularly than children without SLD. This is not necessarily the case, however, since English spellings are not always regular which is why a child needs to be able to spell by the lexical route as well as phonetically in order to be a competent speller.

What this result shows is one level at which the two groups differ in non-lexical spelling. Barry and Seymour's original finding was that, in the spelling of nonsense words, the choice of a grapheme was dependent upon contingency; that is, phoneme-grapheme correspondences that occur more frequently in English are more likely to be chosen. The above result indicates that a child with SLD is possibly less sensitive to English contingency than a child whose reading and writing level is normal for their age group.

The phoneme-grapheme grammars of each group can therefore be said to differ with respect to the graphemes that exist for each phoneme. This was one of the individual differences in non-lexical spelling that was hypothesized earlier.

## 5 Conclusion

The studies showed that phoneme-grapheme grammars differ between children with respect to the graphemes used to represent a phoneme - children with SLD are more likely to have graphemes with lower English contingency than children who do not have reading and spelling difficulties. The studies did not provide enough data to test theories of individual differences. The next study will aim to collect enough data per child so that half of the data can be used to generate a phoneme-grapheme grammar for that child, and the other half can be used to test that grammar.

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# Appendix A

The nonsense words for consistent and inconsistent vowels used in the pilot study are shown below.

## (i) Consistent Vowels.

| *Phoneme* | *Nonsense word* | *Example of rhyming real word* |
|---|---|---|
| /i/ | vip | pip |
| /e/ | ked | red |
| /ae/ | fap | nap |
| /c/ | rop | hop |
| /^/ | lun | bun |

## (ii) Inconsistent Vowels.

| *Phoneme* | *Nonsense word* | *Example of rhyming real word* |
|---|---|---|
| /i:/ | feek | seek |
| /c:/ | sork | pork |
| /u:/ | toon | moon |
| /e:/ | serk | jerk |
| /ai/ | pite | light |
| /ou/ | yope | rope |
| /ei/ | pate | late |
| /u/ | tull | wool |
| /au/ | houd | loud |
| /ci/ | moyal | oil |

## Appendix B

The nonsense words used in the main study are shown below. They are listed by phoneme.

/ei/ *kade nate sate dade tade nade jate hade pate*

/i:/ *keet jeed teed jeed reet leet peed deet*

/ai/ *pite mide fide kide nide jite jide dite*

/ou/ *fode jote jode pote fote sote dode lote pode*

/u:/ *lood woot foot tood poot doot nood joot hood noot*

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